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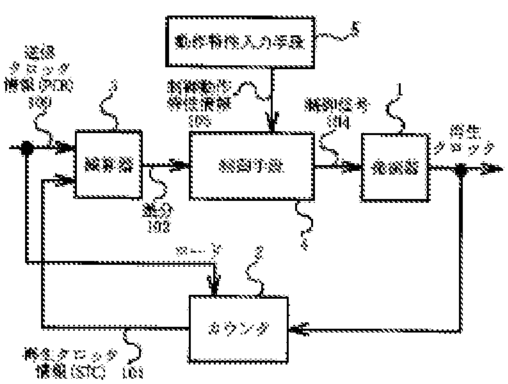
(54) [Title] CLOCK REPRODUCTION DEVICE AND CLOCK REPRODUCTION METHOD

(57) Abstract

[Problem] To perform optimum clock reproduction control under various conditions for a clock reproduction device that reproduces on the receiving side the same clock as that on the transmitting side .

[Means to solve] An operating characteristic input means 5 is provided, and by reporting information such as the transmission clock reception interval or the transmission path fluctuation to a control means 4 that controls clock reproduction, the operating characteristic of the control means is changed and optimal control of clock reproduction is performed according to the situation.



[See figure at the end of the patent for translation.]

[There are no amendments to this patent.]

Claims

1. A clock reproduction device characterized in that it is equipped with a reproduction clock output means that outputs a reproduction clock; a clock difference detection means that detects the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency output from the aforementioned reproduction clock output means; a control means that controls the reproduction clock frequency of the aforementioned reproduction clock output means based on the aforementioned difference from this clock difference detection means; and an operating characteristic input means that inputs control operation characteristic information with respect to this control means; and the aforementioned control means controls the reproduction clock frequency of the aforementioned reproduction clock output means based on the control operation characteristic information that is input from this operation characteristic input means.

2. The clock reproduction device recorded in Claim 1, characterized in that the aforementioned operating characteristic input means is equipped with a fluctuation information setting means that sets and outputs as control operation characteristic information, fluctuation information that adds to the aforementioned difference, and the aforementioned control means controls the reproduction clock frequency based on the fluctuation information that is set with this fluctuation information setting means.

3. The clock reproduction device recorded in Claim 2, characterized in that the aforementioned control means is equipped with a gain means that generates a control signal for the aforementioned reproduction clock output means based on the aforementioned difference that is input, and based on the fluctuation information that is set with the aforementioned fluctuation information setting means, the gain of the aforementioned gain means is made large when the fluctuation is small and the gain is made small when the fluctuation is large.

4. The clock reproduction device recorded in Claim 2 or 3, characterized in that the aforementioned control means is equipped with a low-pass filter processing means that extracts the low-frequency component of the aforementioned difference that has been input, and based on the fluctuation information that is set with the aforementioned fluctuation information setting means, the cutoff frequency of the aforementioned low-pass filter processing means is made high when the fluctuation is small and the cutoff frequency is made low when the fluctuation is large.

5. The clock reproduction device recorded in any of Claim 2 through 4, characterized in that as the aforementioned fluctuation information setting means, it is equipped with a fluctuation detection means that detects the size of the fluctuation by calculating the time rate of change in the difference as well as the rate of change thereof, and that sets [said size] as fluctuation information is provided.

6. The clock reproduction device recorded in Claim 1, characterized in that the aforementioned operating characteristic input means is equipped with a reproduction clock status-setting means that sets [information indicating] that the aforementioned reproduction clock is in a stable state, and the aforementioned control means controls the reproduction clock frequency based on the reproduction clock status that is set in this reproduction clock stable [sic] status-setting means.

7. The clock reproduction device recorded in Claim 6, characterized in that the aforementioned control means is equipped with a low-pass filter processing means that removes the low-frequency component of the aforementioned difference that has been input, and when the setting of the aforementioned reproduction clock status-setting means is set [to indicate] that the reproduction clock is stable, the cutoff frequency of the aforementioned low-pass filter processing means is set low.

8. The clock reproduction device recorded in Claim 6 or 7, characterized in that it is equipped with a difference change rate detection means that detects the time rate of change in the difference that is output from the aforementioned clock difference detection means, and that sets [information indicating] that the aforementioned reproduction clock is stable when this time rate of change is smaller than a prescribed value.

9. The clock reproduction device recorded in Claim 8, characterized in that the aforementioned operating characteristic input means is equipped with a fluctuation information setting means that sets and outputs as control operation characteristic information, fluctuation information that adds to the aforementioned difference, and the aforementioned difference change rate detection means sets the aforementioned prescribed value based on the fluctuation information that is set with this fluctuation information setting means.

10. The clock reproduction device recorded in Claim 1, characterized in that the aforementioned operating characteristic input means is equipped with a reception interval setting means that sets and outputs as control operation characteristic information, the interval at which the aforementioned transmission clock information is received, and the aforementioned control means controls the reproduction clock frequency based on the reception interval that is set with this reception interval setting means.

11. The clock reproduction device recorded in Claim 10, characterized in that the aforementioned control means is equipped with a gain means that generates a control signal for the aforementioned reproduction clock output means based on the aforementioned difference that has been input, with the gain of the aforementioned gain means being made large when the reception interval set with the aforementioned reception interval setting means is small, and the gain being made small when the aforementioned reception interval is large.

12. The clock reproduction device recorded in Claim 10 or 11, characterized in that it is provided with a reception interval detection means that detects and sets as the aforementioned reception interval, the interval at which the aforementioned transmission clock information is received.

13. A clock reproduction method characterized in that the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on fluctuation information that has been set.

14. A clock reproduction method characterized in that the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on the reproduction clock status that has been set.

15. A clock reproduction method characterized in that the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on the reception interval that has been set.

<u>Detailed explanation of the invention</u>

[0001]

Technical field of the invention

This invention pertains to a clock reproduction method whereby clock information transmitted from a transmitting side is used to reproduce the transmitting-side clock on the receiving side in a device that performs communication or broadcasting.

[0002]

Prior art

For example, Figure 17 shows the configuration of a conventional clock reproduction device such as is shown in Recommendation H.222.0 (pp. 182-184) of the ITU-T White Book, Audiovisual/Multimedia Related (H Series) Recommendations (February 18, Hei 7[1995], the ITU Association of Japan). In the figure, 11 is a voltage control oscillator; 12 is a counter that is operated with a reproduction clock output from this voltage oscillator 11; 13 is a subtracter; and 14 is a low-pass filter and gain [means].

[0003]

In the aforementioned Recommendation, the clock information that is output from the transmitting side is called the PCR (program clock reference), and the clock information reproduced at the receiving side is called the STC (system time clock); the PCR is the counter value of a counter that operates with the clock used on the transmitting side, and the STC is the counter value of the aforementioned counter 12 that operates with the clock that is reproduced on the receiving side. Furthermore, 15 is the difference between the PCR and STC obtained with the aforementioned subtracter 13, and 16 is a control voltage that is output from low-pass filter and gain [means] 14 to the aforementioned control oscillator 11.

[0004]

Next, the operation will be explained. When the transmitting-side clock is reproduced on the receiving side, the transmission clock information (PCR) 100 that arrives first is loaded into counter 12. Counter 12 performs a count operation with the reproduction clock that is output from voltage control oscillator 11. When the second PCR 100 arrives, the reproduction clock information (STC) 101 that is the output from counter 12 at this point in time is input to subtracter 13, and the difference 15 with respect to the second PCR 100 that has arrived is obtained.

[0005]

PCR 100 is a counter value that operates with the transmitting device's clock, and STC 101 is a counter value that operates with the receiving device's clock, so the difference between PCR 100 and STC 101 indicates a quantity that depends on the difference in frequency between the transmitting device's clock and the receiving device's clock. For example, if the transmitting device's clock frequency is 20 Hz higher than the receiving device's clock frequency, then the increase in the count value of PCR 100 in one second will be 20 more than the increase in the count value of STC 101. Accordingly, if the difference 10 [sic; 15] between PCR 100 and STC 101 for the previous time and for this time is the same value, the number of counts in the same amount of time will be the same, so the frequency is the same.

[0006]

If this difference is the same every time PCR 100 arrives, it indicates that the count progression conditions have become the same – in other words, that the transmitting-side frequency and the reproduction frequency are the same, the difference 15 that is output from subtracter 13 is converted to a control voltage 16 at low-pass filter and gain [means] 14, the frequency of voltage control oscillator 11 changes, and in response thereto the output of counter

12 changes, and the amount of change in the difference between PCR 100 and STC 101 gradually decreases.

[0007]

By repeating the aforementioned operation every time PCR 100 arrives and controlling the frequency of voltage control oscillator 13 such that the output from subtracter 13 (the difference between PCR 100 and STC 101) becomes fixed – in other words, such that the value counted up [sic; possibly, 'incremental value'] is identical to that of the transmitting side at the same time, a clock with the same frequency as the transmitting side is reproduced.

[0008]

In a stable situation wherein a clock with the same frequency as the transmitting side is reproduced, normally the difference between PCR 100 and STC 101 maintains a fixed value (offset). This is because initially PCR 100 is loaded into counter 12, so there is no offset at this point, but since this is prior to the reproduction operation for the transmitting-side frequency, the transmitting-side frequency and the reproduction frequency are not in synch, and PCR 100 and the counter value gradually deviate, and in response to a reproduction operation, the reproduction frequency is controlled such that the difference achieves a fixed value; thus, in a stable situation, an offset exists.

[0009]

Furthermore, when a network is used to perform communication – for example, when the data for multiple communication devices are multiplexed and transmitted with an ATM (asynchronous transmission mode) network, and when the transmission of data is requested simultaneously by multiple devices, the network is unable to transmit simultaneously, so data are transmitted sequentially. Consequently, the transmitting terminal's transmission data temporarily remain in the network, and the transmission interval for the data transmitted from the transmitting device cannot be preserved at the receiving terminal. This type of situation is known as 'fluctuation in the transmission path (network)'.

[0010]

When fluctuation exists in the transmission path in this manner, the reception timing for the PCR also fluctuates due to the transmission path fluctuation, and due to this fluctuation in the reception timing for the PCR, the difference 15 no longer accurately represents the difference between the transmitting-side and receiving-side clock frequencies. In other words, this difference 15 indicates a value for which a fluctuation is additionally added to the difference

between the transmitting-side and receiving-side frequencies, and thus the clock cannot be properly reproduced. Therefore, the fluctuation component is removed from difference 15 by low-pass filter and gain [means] 14, and stable clock reproduction can be performed.

[0011]

Furthermore, when a communication transmission path (generally, [for] satellite communication, terrestrial waves, cable, or the like) for which a fixed time slot has been allocated is used, almost no fluctuation occurs. On the other hand, fluctuation does occur with a transmission path for which the communication paths are transmitted irregularly, and with the aforementioned ATM network and, for example, internet transmission paths, a large fluctuation occurs.

[0012]

Problems to be solved by the invention

With a conventional clock reproduction device as described above, when only the difference between the transmission clock information (PCR) and the reproduction clock information (STC) is used to express the difference between the transmitting/receiving frequencies, control is performed by inputting [that difference] to the low-pass filter and gain [means] regardless of the reception interval for the transmission clock information, so if the difference is the same, then an identical control voltage is output.

[0013]

However, the difference between the transmission clock information and the reproduction clock information is proportional to the reception interval for the transmission clock information, so when the same difference in frequency exists, the difference value that is output differs according to the length of the transmission interval of the transmission clock information; however, the control voltages with respect to the oscillator for the purpose of correcting the same frequency difference must be identical.

[0014]

Accordingly, when the input (difference 15) differs due to different transmission intervals for the transmission clock information, even if the frequency difference is the same, different control voltages 16 will be output when the same low-pass filter and gain [means] is used, and this is not preferable. Therefore, there is a problem in that it is necessary to perform optimization such that an appropriate control voltage that corresponds to the frequency difference is always output in accordance with the transmission interval for the transmission clock information.

[0015]

Furthermore, a fluctuation also is included in the clock difference due to transmission path fluctuation, so when the cutoff frequency of the low-pass filter is set low to remove that fluctuation, the tracking of the reproduction clock with respect to the reception clock becomes sluggish and time is required to [achieve] normal clock reproduction. Accordingly, there is a problem in that an optimization corresponding to the amount of transmission path fluctuation must be performed.

[0016]

Means to solve the problems

The clock reproduction device according to this invention is equipped with a reproduction clock output means that outputs a reproduction clock; a clock difference detection means that detects the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency output from the aforementioned reproduction clock output means; a control means that controls the reproduction clock frequency of the aforementioned reproduction clock output means based on the aforementioned difference from this clock difference detection means; and an operating characteristic input means that inputs control operation characteristic information with respect to this control means; and the aforementioned control means controls the reproduction clock frequency of the aforementioned reproduction clock output means based on the control operation characteristic information that is input from this operation characteristic input means.

[0017]

Furthermore, [this invention] is one such that the aforementioned operating characteristic input means is equipped with a fluctuation information setting means that sets and outputs as control operation characteristic information, fluctuation information that adds to the aforementioned difference, and the aforementioned control means controls the reproduction clock frequency based on the fluctuation information that is set with this fluctuation information setting means.

[0018]

Furthermore, [this invention] is one wherein the aforementioned control means is equipped with a gain means that generates a control signal for the aforementioned reproduction clock output means based on the aforementioned difference that is input, and based on the

fluctuation information that is set with the aforementioned fluctuation information setting means, the gain of the aforementioned gain means is made large when the fluctuation is small and the gain is made small when the fluctuation is large.

[0019]

Furthermore, [this invention] is one wherein the aforementioned control means is equipped with a low-pass filter processing means that extracts the low-frequency component of the aforementioned difference that has been input, and based on the fluctuation information that is set with the aforementioned fluctuation information setting means, the cutoff frequency of the aforementioned low-pass filter processing means is made high when the fluctuation is small and the cutoff frequency is made low when the fluctuation is large.

[0020]

Furthermore, [this invention] is one that is equipped with, as the aforementioned fluctuation information setting means, a fluctuation detection means that detects the size of the fluctuation by calculating the time rate of change in the difference as well as the rate of change thereof, and that sets [said size] as fluctuation information is provided.

[0021]

Furthermore, [this invention] is one wherein the aforementioned operating characteristic input means is equipped with a reproduction clock status-setting means that sets [information indicating] that the aforementioned reproduction clock is in a stable state, and the aforementioned control means controls the reproduction clock frequency based on the reproduction clock status that is set in this reproduction clock stable [sic] status-setting means.

[0022]

Furthermore, [this invention] is one wherein the aforementioned control means is equipped with a low-pass filter processing means that removes the low-frequency component of the aforementioned difference that has been input, and when the setting of the aforementioned reproduction clock status-setting means is set [to indicate] that the reproduction clock is stable, the cutoff frequency of the aforementioned low-pass filter processing means is set low.

[0023]

Furthermore, [this invention] is one that is equipped with a difference change rate detection means that, as the aforementioned clock status-setting means, detects the time rate of change in the difference that is output from the aforementioned clock difference detection means,

and that sets [information indicating] that the aforementioned reproduction clock is stable when this time rate of change is smaller than a prescribed value.

[0024]

Furthermore, [this invention] is one wherein the aforementioned operating characteristic input means is equipped with a fluctuation information setting means that sets and outputs as control operation characteristic information, fluctuation information that adds to the aforementioned difference, and the aforementioned difference change rate detection means sets the aforementioned prescribed value based on the fluctuation information that is set with this fluctuation information setting means.

[0025]

Furthermore, [this invention] is one wherein the aforementioned operating characteristic input means is equipped with a reception interval setting means that sets and outputs as control operation characteristic information, the interval at which the aforementioned transmission clock information is received, and the aforementioned control means controls the reproduction clock frequency based on the reception interval that is set with this reception interval setting means.

[0026]

Furthermore, [this invention] is one wherein the aforementioned control means is equipped with a gain means that generates a control signal for the aforementioned reproduction clock output means based on the aforementioned difference that has been input, with the gain of the aforementioned gain means being made large when the reception interval set with the aforementioned reception interval setting means is small, and the gain being made small when the aforementioned reception interval is large.

[0027]

Furthermore, [this invention] is one that is provided with a reception interval detection means that detects and sets as the aforementioned reception interval, the interval at which the aforementioned transmission clock information is received.

[0028]

Moreover, the clock reproduction method according to this invention is one wherein the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is

detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on fluctuation information that has been set.

[0029]

Furthermore, another clock reproduction method according to this invention is one wherein the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on the reproduction clock status that has been set.

[0030]

Furthermore, another clock reproduction method according to this invention is one wherein the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on the reception interval that has been set.

[0031]

Embodiment of the invention

Embodiment 1

Figure 1 is a block diagram showing Embodiment 1 of a clock reproduction device according to this invention. 1 is an oscillator [used] as a reproduction clock output means that outputs a reproduction clock, and 2 is a counter that operates with the reproduction clock from this oscillator, outputting the count value thereof as reproduction clock [information] 101. Since counter 2 operates with the reproduction clock of oscillator 1, this reproduction clock information 101 is information indicating the frequency thereof.

[0032]

3 is a subtracter [used] as a transmission clock information reception means and a clock difference detection means; it receives the transmission clock information 100, and detects and outputs the difference 102 between the received transmission clock information 100 and the reproduction clock information 101 output from the aforementioned counter 2.

[0033]

4 is a control means that outputs a control signal 104 that controls the reproduction clock of the aforementioned oscillator 1 based on difference 102 from subtracter 3. 5 is an operating

characteristic input means for the purpose of inputting/setting information pertaining to the control operation characteristic for the aforementioned control means 4.

[0034]

Next, the operation will be explained. When clock reproduction starts with this clock reproduction device, first, the transmission clock information 100 that is input to subtracter 3 is loaded into counter 2. The arrival of the transmission clock information, [which is used] as the timing for this loading, can be detected by means of a flag of a prescribed bit in the signal line or the time series with which transmission clock information 100 is transmitted; or [the timing] can be recognized with a signal line (not shown in the figure) that indicates the arrival.

[0035]

The loaded counter 2 value is output to subtracter 3 as reproduction clock information 101 (at this time, reproduction clock 101 = transmission clock 100). Furthermore, counter 2 starts from this loaded value, and the counting operation proceeds based on the reproduction clock from oscillator 1. If a second piece of transmission clock information 100 has arrived, the difference between that transmission clock information 100 and the aforementioned reproduction clock information 101 from counter 2 is obtained by subtracter 3, and a difference 102 is output as the difference between the [respective pieces of] information indicating the transmitting-side and receiving-side clock frequencies.

[0036]

Furthermore, operating characteristic input means 5 is capable of inputting information pertaining to the operating characteristic with respect to control means 4, and that information is [then] set in control means 4. Based on the operating characteristic that has been set by operating characteristic input means 5, control means 4 generates control information 104 for oscillator 1 from difference 102. Furthermore, control means 4 holds clock information difference 102.

[0037]

Various methods can be considered for the creation of control signal 104 by control means 4, but with this invention, control means 4 performs control so as to attain optimal clock reproduction for oscillator 1 by generating control signal 104 based on the control operation characteristic information 105 that is input from operating characteristic input means 5.

[0038]

Next, a case wherein this control means 4 is comprised of a low-pass filter and gain function will be explained. Figure 2 is a block diagram showing an example of the structure of control means 4. In this case. 21 is a low-pass filter [used] as a low-pass filter processing means that removes the low-frequency component from difference 102. This low-pass filter 21 can be comprised of an H/W circuit, or can be comprised of an S/W. In terms of function, it is sufficient to have a function whereby the low-frequency component is removed; for example, as long as the level suddenly changes in difference 102, it can be one that obtains the arithmetic average of difference 102, one that obtains an average by weighting, or the like.

[0039]

22 is a gain means that amplifies the difference 102 that has passed through the aforementioned low-pass filter 21 and generates a control signal 104 for oscillator 1. 23 is a coefficient-setting means that sets an operating coefficient for low-pass filter 21 and gain means 22 based on control operation characteristic information 105 from operating characteristic input means 5.

[0040]

This operation whereby control means 4 generates control signal 104 from difference 102 basically is identical to that of the prior art; a control signal (voltage) is generated to adjust the frequency of oscillator 1 so that the difference thereof is fixed (the difference is fixed if the transmitting-side and receiving-side frequencies are identical) in accordance with difference 102. For example, if the count-up of the reproduction clock with respect to the transmission clock is small and difference 102 has gradually become large, then the voltage that is output to the oscillator is increased in proportion to the increase in difference 102, and the oscillator frequency is raised so that the reproduction clock frequency approaches the transmission clock frequency. When difference 102 is stable (when the reproduction clock and transmission clock frequencies are identical), gain means 22 will amplify the signal from low-pass filter 21 with a fixed gain.

[0041]

Next, the function of low-pass filter 21 will be explained. Figure 3 shows the frequency characteristic for low-pass filter 21. Low-pass filter 21 cuts a high-frequency signal by making the cutoff frequency low. In other words, sharp temporal changes in difference 102 are smoothed and then are output, so the output signal does not slavishly follow sudden changes in the input (difference 102), and when the output signal does change with respect to the input, the temporal change thereof assumes a smooth curve. Furthermore, a high-frequency signal is not cut very

much when the cutoff frequency is high, so high-frequency noise and the like cannot be cut; however, [the output signal] slavishly follows sudden changes in the input (difference 102), so when the output signal changes with respect to the input, the output signal is able to assume a sharp curve.

[0042]

Low-pass filter 21 has an effect of removing the error included in difference 102 that is caused by fluctuation generated in the transmission path between the transmitting and receiving devices. By making the cutoff frequency of low-pass filter 21 small when the transmission path fluctuation is large, control signal 104 is smoothed, so the reproduction clock fluctuates very little even if the transmission path fluctuates. In addition, by making the cutoff frequency of the low-pass filter large when the transmission path fluctuation is small, control signal 104 is capable of assuming sharp values [sic passim; possibly, 'sharp changes in value'], so the reproduction clock is able to quickly follow the transmission clock.

[0043]

Furthermore, as described above, low-pass filter 21 smoothes out temporal changes in difference 102, so sudden changes are not imparted to control signal 104, which is for the purpose of controlling the reproduction clock so as to synchronize with the transmission clock. Therefore, time is required to synchronize the clocks. Accordingly, with the operation for the purpose of establishing synchronization, it is preferable that the cutoff frequency of the low-pass filter be made large, so that control signal 104 can change quickly and the reproduction clock can quickly follow the transmission clock.

[0044]

As described above, with this invention the reproduction clock is controlled appropriately according to the situation by setting the operating characteristic (cutoff frequency) of low-pass filter 21 according to various conditions such as the transmission path fluctuation and the status of the synchronization operation, and the cutoff frequency of low-pass filter 21 can be set as [sic; with] control operation characteristic information 105 from operating characteristic input means 5, for example.

[0045]

Next, the function of gain means 22 will be explained. Normally the frequency increase/decrease of oscillator 1 is almost proportional to control signal 104. Therefore, if the difference between the transmission clock and reproduction clock frequencies is known, a

control signal that causes an increase/decrease by just that frequency difference can be supplied with respect to the reproduction clock.

[0046]

Figure 4 is a diagram explaining change in the frequency difference over time; it shows that the state of that change differs according to the size of the gain. When the gain is large, the frequency change is large, so it is possible to approach the desired frequency quickly. However, when the gain is too large, the frequency changes by more than the frequency difference, so oscillation will occur. Furthermore, when the gain is large, it diverges. If the gain is small, the frequency change is small, so when the reproduction clock is almost synchronized with the transmission clock, the reproduction clock can be kept stable and, for example, it is possible to suppress deviation in response to the aforementioned fluctuation in the transmission path. However, when the gain is too small, time is required to synchronize the clocks.

[0047]

As described above, with this invention, the reproduction clock is controlled appropriately according to the situation by setting the operating characteristic (gain) of gain means 22 according to various conditions such as the transmission path fluctuation and the status of the synchronization operation, and the operating characteristic (gain) of gain means 22 can be set as [sic; with] control operation characteristic information 105 from operating characteristic input means 5, for example.

[0048]

[In the above,] cases were explained whereby the operating characteristics of low-pass filter 21 and gain means 22 can be changed by control means 4, but when the characteristics of those functions [sic] cannot easily be changed, the same effect can be achieved by providing multiple low-pass filters or gain [means] having different characteristics, and by using a selector or the like to select and use the low-pass filer or gain [means] having the optimal characteristic.

[0049]

Furthermore, with clock reproduction of this type, generation of the control signal for oscillator 1 can be implemented wholly or partially with software. Figure 5 is a flowchart showing such a case.

[0050]

First, in step S1, the transmission clock information is received. The transmission clock information that is first received is loaded into a counter that operates with the reproduction clock. In step S2, the clock difference information is detected based on the received transmission clock information and the value (reproduction clock information) of the counter that operates with the reproduction clock, and [this difference] is stored. In step S3, the control operation characteristic information is read and is set as the characteristic (for example, the characteristic of the low-pass filter and the gain) [to be used] when control information is subsequently generated.

[0051]

In step S4, control [information] for the reproduction clock is generated based on the clock information difference obtained in step S2. For example, the control information is generated by multiplying the low-pass filter [sic; possibly, 'output of the low-pass filter'] by the clock information difference using the low-pass filter characteristic that was set in step S3, and then multiplying that value by the gain that also has been set in the aforementioned manner. Then, in step S5, the reproduction clock frequency is controlled by means of the control information obtained in step S4. The clock is reproduced by repeating this operation every time transmission clock information is received.

[0052]

Embodiment 2

As an example of the structure of operating characteristic input means 5, a case will be explained wherein a fluctuation information setting means is provided to set information about fluctuation existing in the transmission path. As described above, it is preferable that a stable reproduction clock be obtained by effectively suppressing the effect of fluctuation in the transmission path by means of low-pass filter 21, or by appropriately setting the gain so that [the output signal] does not vary according to the transmission path fluctuation.

[0053]

Therefore, by inputting control operation characteristic information 105 from operating characteristic input means 5 that takes into account the size of the transmission path fluctuation, control means 4 is able to control the reproduction clock in accordance with the size of the fluctuation. Figure 6 is a block diagram illustrating a case wherein operating characteristic input means 5 is equipped with a fluctuation information setting means 51. Next, a case in which the

gain of gain means 22 in Figure 2 is adjusted based on the size of the fluctuation will be explained.

[0054]

The transmission path fluctuation is measured in advance, for example, and set in fluctuation information setting means 51. Based on the fluctuation that is set in fluctuation information setting means 51, operating characteristic input means 5 transmits to control means 4 control operation characteristic information 105 such that the gain is small when the fluctuation is large and the gain is large when the fluctuation is small. Because the gain is small when the fluctuation is large, the clock can be reproduced in a stable manner; because the gain is large when the fluctuation is small, the clocks can be synchronized quickly.

[0055]

Next, a case wherein the cutoff frequency of low-pass filter 21 in Figure 2 is adjusted based on the size of the fluctuation will be explained. As described above, low-pass filter 21 has an effect of removing the error included in difference 102 that is caused by fluctuation generated in the transmission path between the transmitting and receiving devices. Based on the fluctuation that is set in fluctuation information setting means 51, operating characteristic input means 5 transmits control operation characteristic information 105 to control means 4 so as to make the cutoff frequency small when the fluctuation is large and make the cutoff frequency large when the fluctuation is small.

[0056]

By making the cutoff frequency of low-pass filter 21 small when the transmission path fluctuation is large, control signal 104 is smoothed, so the reproduction clock fluctuates very little even if the transmission path fluctuates. In addition, by making the cutoff frequency of the low-pass filter large when the transmission path fluctuation is small, control signal 104 is capable of assuming sharp values, so the reproduction clock is able to quickly follow the transmission clock.

[0057]

In the above, a case was explained wherein the fluctuation information was set in advance; next, a case in which the fluctuation is detected will be explained. Figure 7 is a block diagram illustrating a case wherein operating characteristic input means 5 is equipped with a fluctuation detection means 52 that detects the size of the fluctuation from difference 102. Next, the operation will be explained. The difference 102 that is output from subtracter 3 is input to

fluctuation detection means 52. At fluctuation detection means 52 the fluctuation is detected from the of [sic] difference 102. As described previously, when there is fluctuation in the transmission path, the difference information also contains fluctuation (error), so the size of the fluctuation can be determined using this fact.

[0058]

If clock reproduction occurs when there is no fluctuation in the transmission path, the result of the clock reproduction operation by control means 4 is that the historical temporal change in the difference transitions smoothly toward a given difference value, and a fixed value is maintained in a stable (locked) state. However, when there is fluctuation in the transmission path, the temporal change in the difference transitions toward a given difference value while pulsating with an amplitude that is based on the fluctuation. The pulsating portion is the portion that is related to the transmission path fluctuation.

[0059]

Figure 8(a) is an explanatory diagram showing one example of the temporal change in difference 102 when fluctuation exists in the transmission path. The points indicate the difference, and the figure shows this difference information connected with a smooth curve, but this is the curve that is expected when there is no fluctuation in the transmission path and the difference changes over time. The distance between this curve and the actual difference values (the points in the figure) increases as the fluctuation increases. The difference error increases as the fluctuation increases, so the distance increases. The size of the transmission path fluctuation can be derived by deriving a curve from the received difference and [making a calculation] based on the difference [exhibited by that curve] with respect to the actual difference.

[0060]

As described previously, the cutoff frequency of low-pass filter 21 and the gain of gain means 22 can be controlled using the derived size of the fluctuation. Thus, it is possible for control means 4 to perform optimal control of clock reproduction automatically even when the size of the fluctuation changes, such as when the state of the transmission path changes or when the reception device is connected to a different transmission path.

[0061]

Next, a specific example will be explained wherein the size of the fluctuation is detected by the aforementioned fluctuation information setting means 52. Figure 9 is a block diagram illustrating this case; fluctuation detection means 52 is equipped with a difference change rate

detection means 53 that detects the time rate of change in difference 102. This difference change rate detection means 53 obtains the time rate of change (the difference differentiated along the time axis) of difference 102. Figure 8(b) is an explanatory diagram showing one example of the change in the rate of change in the difference; the points are the rate of change in the difference. As shown by the curve in the figure, when there is no transmission path fluctuation, the time rate of change in the difference smoothly approaches 0. In other words, the change in the difference disappears, and [the difference] becomes a fixed value. However, when transmission path fluctuation exists, the difference is always changing, and neither the change nor the rate of change in the difference converges. The rate of change in the difference approaches 0, but it constantly moves up and down [by] just the amount of fluctuation, while centered on 0.

[0062]

Based on this time rate of change in the difference, fluctuation detection means 52 further determines the rate of change thereof. When there is fluctuation and if the reproduction clock is virtually stable, the result thereof (the rate of change in the time rate of change in the difference) straddles 0, moving between a positive value and a negative value. (With the example in Figure 8(b), the direction of change in the rate of change in the difference alternates between increasing and decreasing, so that the rate of change also alternately assumes positive and negative values.) When the amplitude of the change in the time rate of change in the difference is pulsating, that can be used as the size of the fluctuation. In other words, even when there is no fluctuation in the transmission path, there is some change in the difference because the clock is reproduced; however, when there is fluctuation, it is expected that a change will occur that is as large as the degree to which the [arithmetic] sign of the time rate of change in the difference is inverted, and this is used as the fluctuation. Thus, optimal control of the reproduction clock can be preformed automatically.

[0063]

<u>Embodiment 3</u>

Next, an example of the structure of operating characteristic input means 5 will be explained wherein a reproduction clock status-setting means is provided to set [information indicating] that the reproduction clock is stable. Figure 10 is a block diagram illustrating a case wherein operating characteristic input means 5 is equipped with a reproduction clock status-setting means 54. Normally clock reproduction control is divided into control for the purpose of aligning the clock and control for the purpose of stable (no fluctuation) clock reproduction after the clock has been aligned (locked). To align the clock quickly, it is necessary to improve the tracking of the reproduction clock with respect to the transmission clock, and stable clock

reproduction can be achieved by minimizing the time rate of change in the clock (degrading the tracking performance).

[0064]

Therefore, a control of clock reproduction by control means 4 that corresponds to the status of the reproduction clock is performed by inputting from operating characteristic input means 5 a piece of control operation characteristic information 105 that takes into account whether the reproduction clock is locked.

[0065]

The status of the reproduction clock can be set, for example, by assuming that the reproduction clock has locked after a prescribed period of time has elapsed since the reception device has begun operating, and by providing and setting in advance – as reproduction clock status-setting means 54 – a timer that keeps the elapsed time and a means for inputting that prescribed period of time. Furthermore, as will be explained later, the reproduction clock status can be detected and set dynamically. When reproduction clock status-setting means 54 is set [to indicate] that the reproduction clock has locked, operating characteristic input means 5 transmits control operation characteristic information 105 to control means 4 such that the cutoff frequency of low-pass filter 21 is made small. Consequently, control signal 104 becomes smooth (with little change), and stable clock reproduction can occur. Conversely, by making the cutoff frequency of the low-pass filter large prior to the locking of the clock, tracking of the reproduction clock with respect to the received transmission clock can be improved.

[0066]

As described above, stable clock reproduction (without fluctuation) can be achieved by detecting that the clock has locked and then making the cutoff frequency of the low-pass filter in the control means small.

[0067]

Next, a case will be explained wherein the reproduction clock status is detected dynamically from difference 102. Figure 11 is a block diagram illustrating a case wherein operating characteristic input means 5 is provided with a difference change rate detection means 55 that, as the reproduction clock status-setting means, detects the time rate of change from difference 102. This difference change rate detection means 55 is identical to the difference change rate detection means 53 that was explained with Figure 9 and is for the purpose of detecting the size of the fluctuation.

[0068]

First, the difference 102 that is output from subtracter 3 is input to difference change rate detection means 55. Difference change rate detection means 55 detects the change over time in the difference 102 that has been input. An example of the change over time in difference 102 is shown in Figure 8(a), with the time rate of change in the difference shown in Figure 8(b). When this temporal change in the difference – in other words, the time rate of change in the difference – stays within a fixed range, difference change rate detection means 55 concludes that the clock has locked and makes a setting [indicating] that the reproduction clock is stable. Deviation within the fixed range can be assumed to be due to transmission path fluctuation.

[0069]

When a setting [indicating] that the reproduction clock is stable has been made, operating characteristic input means 5 transmits control operation characteristic information 105 to control means 4 such that the cutoff frequency of low-pass filter 21 is made small. Consequently, control signal 104 becomes smooth (with little change), and stable clock reproduction can occur.

[0070]

As described above, appropriate control of clock reproduction by control means 4 in response to the reproduction clock status can be performed automatically.

[0071]

When it is concluded that the clock has locked, with the present embodiment, the time rate of change in the difference information is used, but if there is fluctuation in the transmission path, the difference information also contains fluctuation (error). Consequently, the time rate of change in the difference information also will fluctuate; however, depending on the size of the transmission path fluctuation, it is possible that this time rate of change in the difference may not fall below a given value, and it may not be possible to conclude that the clock has locked. As an example whereby this [problem] is solved, operating characteristic input means 5 can be additionally provided with a fluctuation information setting means 51 such as that explained with Figure 6 and Figure 9, and that fluctuation information can be output to difference change rate detection means 55 to enable difference change rate detection means 55 to set a standard for the size of the change over time in the difference, in order to determine whether the clock has locked. Figure 12 is a block diagram illustrating such a configuration.

[0072]

At difference change rate detection means 55, the size of the change over time in the difference, which is used to determine that the clock has locked, is optimized from [sic; based on] the transmission path fluctuation that has been set in fluctuation information setting means 51, and [thus] it is possible to accurately recognize that the clock has locked. Various relationships between the transmission path fluctuation and recognition of the locking of the clock can be considered. For example, with a method of recognizing that the clock has locked whereby it is concluded that the clock is locked when the difference between the previous and the current difference information is less than or equal to a given value A, the given value A can be made large when then the transmission path fluctuation is large and the given value A can be made small when the fluctuation is small, thus enabling [a method of] recognizing that the clock has locked that corresponds to the fluctuation.

[0073]

Moreover, when fluctuation information is thus used to accurately recognize that the clock has locked, that fluctuation information can be determined using a method such as that explained with Figure 9 and the configuration in Figure 12. This is because, as explained with Figure 9, the size of the fluctuation can be determined by additionally determining the rate of change with respect to the rate of change in the difference that is detected by difference change rate detection means 55. In this case, first the rate of change in the difference is detected by difference change rate detection means 55 and is transmitted to fluctuation information setting means 51, where the rate of change thereof is again determined, thus obtaining the size of the fluctuation. Then, the obtained fluctuation size is returned to difference change rate detection means 55 and is used to judge whether the clock has locked. Furthermore, the configuration can be such that [the process] from detection of the rate of change in the difference to the generation [sic; determination] of the size of the fluctuation occurs in difference change rate detection means 55.

[0074]

Furthermore, when control in response to the status of the reproduction clock such as described above occurs, all or part of [the process] from detection of the reproduction clock status to generation of control signal 104 for oscillator 1 can be implemented with software. As an example thereof, Figure 13 is a flowchart of the process from detection of the rate of change in the difference to specification of the cutoff frequency of low-pass filter 21 as control operation characteristic information.

[0075]

First, in step S10, the clock information difference is received. In Step S11, the aforementioned difference information is stored. When the amount of difference information to be stored is limited, it is deleted beginning with the oldest information. In step S12, the current difference information is compared to the previously stored difference information and the temporal change in the difference information is detected. There are various methods for detecting the temporal change, but as a simple example, when the difference between the previous and the current difference information is smaller than a given value, the rate of change over time is considered small (time rate of change: small), and when it is larger than a given value, the rate of change over time is considered large.

[0076]

In step S13, branching occurs based on the size of the rate of change over time for the clock information difference information [sic] obtained in step S12. When the rate of change over time is large, the current process ends as is. When the rate of change over time is small, the process branches to step S14. In step S14, an instruction to make the cutoff frequency of the low-pass filter low is generated and output to the operation characteristic input means. By repeating this type of operation every time the difference information is received, the characteristic pertaining to clock reproduction is controlled.

[0077]

Embodiment 3

Next an example of the structure of operating characteristic input means 5 will be explained wherein a reception interval setting means is provided to set the interval at which the transmission clock information is received. With the prior art, control means 4 inputs the difference 102 between transmission clock information (PCR) 100 and the reproduction clock information (STC) 101 that is output from counter 2, and oscillator 1 is controlled based on this [information]. However, the size of this difference 102 differs according to the interval at which PCR 100, which is the count information for the transmission clock, is received with respect to [sic; possibly, 'in consideration of'] the difference in frequency that exists between transmission and reception. Accordingly, when a system for which the reception interval for PCR 100 differs is used, or when the reception interval for PCR 100 changes, the characteristic of the low-pass filter and the gain must be changed in response thereto.

[0078]

Therefore, with this embodiment, the reception interval for the transmission clock is set from operating characteristic input means 5, which enables the clock to be reproduced correctly by control means 4. Figure 14 is a block diagram illustrating a case wherein operating characteristic input means 5 is equipped with a reception interval setting means 56. Next, a case will be explained wherein the gain of gain means 22 is adjusted based on the size of the fluctuation. The reception interval is determined according to the specifications of the system being used, and is set appropriately in reception interval setting means 56.

[0079]

Based on the reception interval that has been set in reception interval setting means 56, operating characteristic input means 5 supplies control operation characteristic information to control means 4 such that the gain of gain means 22 is inversely proportional to the reception interval. In other words, with respect to is [sic] the same frequency difference, the value of difference 102 increases as the reception interval increases and the value of difference 102 decreases as the reception interval decreases; therefore, for example, by making the gain small with respect to a difference value that has become large due to a large reception interval, control signal 104, which is the output corresponding thereto, can be output as an appropriate value.

[0080]

Next, a case in which the reception interval is detected dynamically will be explained. Figure 15 is a block diagram illustrating a case wherein a reception interval detection means 57 that detects the reception interval based on the reception timing of PCR 100 is provided. PCR 100 is input to this reception interval detection means 57, the reception interval is detected using an internal timer or the like, and said reception interval is set in reception interval setting means 56.

[0081]

When transmission clock information 100 is input to reception interval detection means 7 [sic; 57] as an input, reception interval detection means 7 [sic; 57] uses an internal timer or the like to record the time at which that transmission clock information is received. Then, the reception interval is calculated by taking the difference between that recorded time and the time that was recorded for the previous reception of the transmission clock information.

[0082]

The value [obtained] by averaging the calculated reception interval one or more times is input to reception interval setting means 56 as the reception interval information. Thus, the reception interval for the transmission clock information is detected automatically, and by using this as described previously to control the gain of gain means 22, clock reproduction can be controlled appropriately and automatically.

[0083]

All or part of this reception interval detection operation can be implemented with software. Figure 16 is a flowchart showing such a case.

[0084]

First, in step S21, the transmission clock information is received. In step S22, the time at which the aforementioned transmission clock information was received is measured by a timer or the like and is saved. In step S23, the reception interval is calculated from the difference between the current reception time and the reception time for the previously received transmission clock information. In step S24, the reception interval information is generated. There are various methods for generating the reception interval information, but as a simple example, an average of any number of reception intervals can be used as the reception interval information. In step S25, the calculated reception interval information is output to the operating characteristic input means. Thus, the reception interval for the transmission clock information is detected automatically and is used to control the gain, and clock reproduction is controlled appropriately and automatically

[0085]

Furthermore, in all of the aforementioned embodiments, a case wherein the characteristics of low-pass filter 21 and gain means 22 were changed by control means 4 was explained; however, [the fact] that the same effect can be achieved by providing multiple low-pass filters or gain [means] having different characteristics and by using a selector or the like to select and use the low-pass filter or gain [means] having the optimal characteristic can be applied to all of the embodiments.

[0086]

Effect of the invention

As described above, by means of this invention, an operating characteristic input means that inputs control operation characteristic information with respect to a control means is provided, and the control means controls the reproduction clock frequency of a reproduction

clock output means based on this control operation characteristic information; therefore, the effect is that optimal control of clock reproduction can be performed in accordance with various conditions.

[0087]

Furthermore, a fluctuation information setting means sets and outputs as control operation characteristic information, fluctuation information that adds to the difference, and the control means controls the reproduction clock frequency based on this fluctuation information; therefore, the effect is that the control of clock reproduction can be performed appropriately in accordance with the size of the transmission path fluctuation.

[0088]

Furthermore, based on the fluctuation information, the gain of the aforementioned gain means is made large when the fluctuation is small, and the gain is made small when the fluctuation is large, so the effect is that stable clock reproduction can be performed or the clocks can be synchronized quickly.

[0089]

Furthermore, based on the fluctuation information, the cutoff frequency of the aforementioned low-pass filter processing means can be set high when the fluctuation is small, and the cutoff frequency can be set low when the fluctuation is large; therefore, the effect is that there is almost no fluctuation in the reproduction clock even when there is transmission path fluctuation, or the reproduction clock can quickly follow the transmission clock.

[0090]

Furthermore, a fluctuation detection means that detects the size of the fluctuation by calculating the time rate of change in the difference that is output from the aforementioned clock difference detection means as well as the rate of change thereof, and that sets [said size] as fluctuation information, is provided; therefore, the effect is that the control of clock reproduction can be performed automatically according to the fluctuation.

[0091]

Furthermore, a reproduction clock status-setting means that sets [information indicating] that the reproduction clock is in a stable state is provided, and the reproduction clock frequency is controlled based on this reproduction clock status; therefore, the effect is that the control of

clock reproduction by the control means can be performed appropriately according to the reproduction clock status.

[0092]

Furthermore, when the reproduction clock status-setting means has been set [to indicate] that the reproduction clock is stable, the cutoff frequency of the low-pass filter processing means is made low; therefore, the effect is that appropriate clock control can be performed after the reproduction clock has stabilized.

[0093]

Furthermore, a difference change rate detection means that detects the time rate of change in the difference that is output from the clock difference detection means and that sets [information indicating] that the reproduction clock is stable when this time rate of change is less than a prescribed value is provided; therefore, the effect is that the control of clock reproduction can be performed appropriately and automatically based on the stable status of the clock.

[0094]

Furthermore, the stable status of the reproduction clock is set based on fluctuation information; therefore, the effect is that the stable status of the reproduction clock can be appropriately judged according to the size of the fluctuation.

[0095]

Furthermore, a reception interval setting means, which sets and outputs as control operation characteristic information the interval at which the transmission clock information is received, is provided, and the control means controls the reproduction clock frequency based on the reception interval; therefore, the effect is that clock reproduction can always be controlled appropriately regardless of the size of the reception interval.

[0096]

Furthermore, the gain of the aforementioned gain means is made large when the reception interval is small and the gain is made small when the aforementioned reception interval is large; therefore, the effect is that clock reproduction can be controlled appropriately according to the reception interval.

[0097]

Furthermore, a reception interval detection means, which detects and sets as the aforementioned reception interval the interval at which the transmission clock information is received, is provided; therefore, the effect is that clock reproduction can be controlled appropriately and automatically according to the reception interval.

[0098]

Moreover, by means of the clock reproduction method according to the present invention, the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on fluctuation information that has been set; therefore, the effect is that clock reproduction can be controlled according to the fluctuation.

[0099]

Furthermore, the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on the reproduction clock status that has been set; therefore, the effect is that clock reproduction can be controlled appropriately based on the stable status of the clock.

[0100]

Furthermore, the difference between transmission clock information that indicates the transmitting-side clock frequency and reproduction clock information that indicates the reproduction clock frequency is detected, and the aforementioned reproduction clock frequency is controlled based on this detected difference and based on the reception interval that has been set; therefore, the effect is that clock reproduction can be controlled appropriately according to the reception interval.

Brief description of the figures

Figure 1 is a block diagram of a clock reproduction device according to an embodiment of this invention.

Figure 2 is a block diagram showing a structural example of the control means within a clock reproduction device according to an embodiment of this invention.

Figure 3 is a diagram explaining the characteristic of a low-pass filter according to an embodiment of this invention.

Figure 4 is a diagram explaining an example of the change over time in the gain value and the frequency difference according to an embodiment of this invention.

Figure 5 is a flowchart illustrating the clock reproduction operation according to an embodiment of this invention.

Figure 6 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 7 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 8 is a diagram explaining examples of the clock information difference and the time rate of change in the difference during clock reproduction control with an embodiment of this invention.

Figure 9 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 10 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 11 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 12 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 13 is a flowchart showing the clock reproduction operation of an embodiment of this invention.

Figure 14 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 15 is a block diagram showing a clock reproduction device according to an embodiment of this invention.

Figure 16 is a flowchart showing the clock reproduction operation of an embodiment of this invention.

Figure 17 is a block diagram of a conventional clock reproduction device.

Explanation of symbols

1 Oscillator

2 Counter

3 Subtracter

4 Control means

5 Operating characteristic input means
21 Low-pass filter
22 Gain means
51 Fluctuation information setting means
52 Fluctuation detection means
53 Difference change rate detection means
54 Reproduction clock status-setting means
55 Difference change rate detection means
56 Reception interval setting means
57 Reception interval detection means

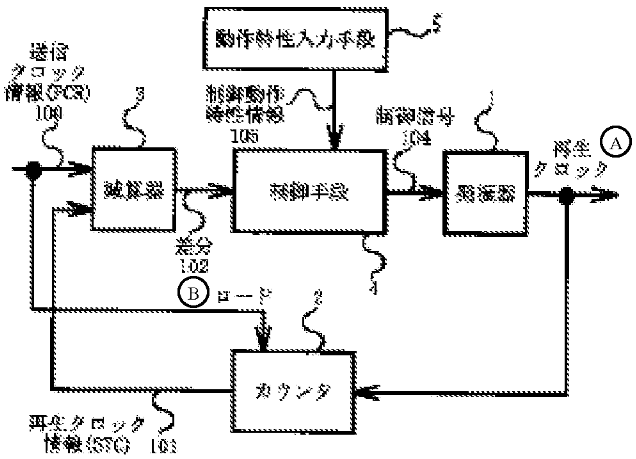


Figure 1

Key:
- A Reproduction clock
- B Load
- 1 Oscillator
- 2 Counter
- 3 Subtracter
- 4 Control means
- 5 Operating characteristic input means
- 100 Transmission clock information (PCR)
- 101 Reproduction clock information (STC)
- 102 Difference
- 104 Control signal
- 105 Control operation characteristic information

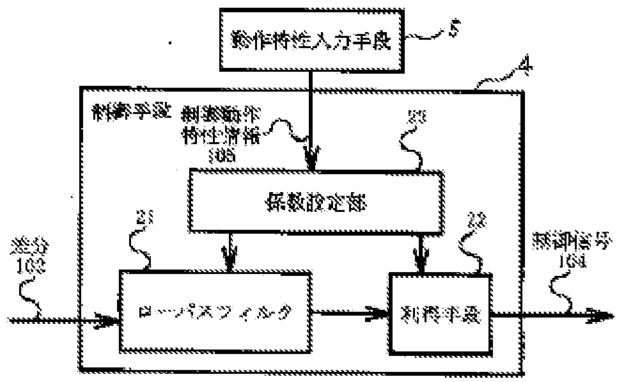


Figure 2

Key:
Key:	5	Operating characteristic input means
	21	Low-pass filter
	22	Gain means
	23	Coefficient-setting unit
	102	Difference
	104	Control signal
	105	Control operation characteristic information

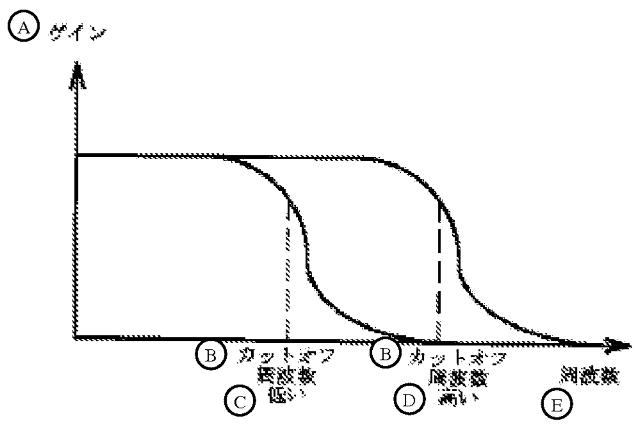


Figure 3

Key:	A	Gain
	B	Cutoff frequency
	C	Low
	D	High
	E	Frequency

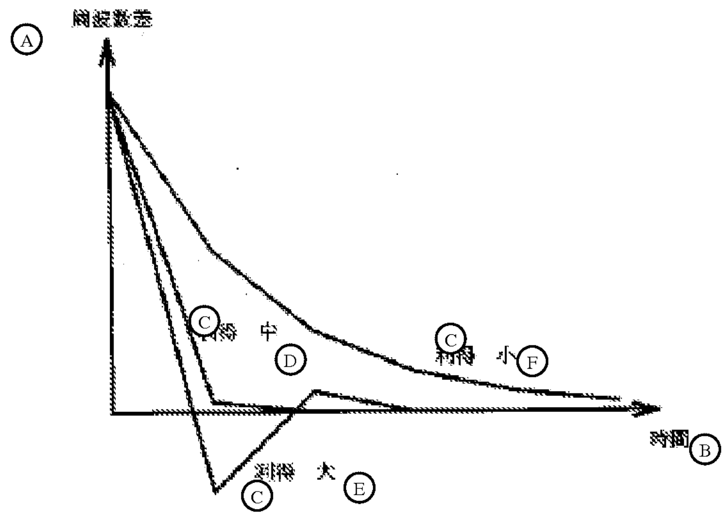


Figure 4

Key:
- A Frequency difference
- B Time
- C Gain
- D Medium
- E Large
- F Small

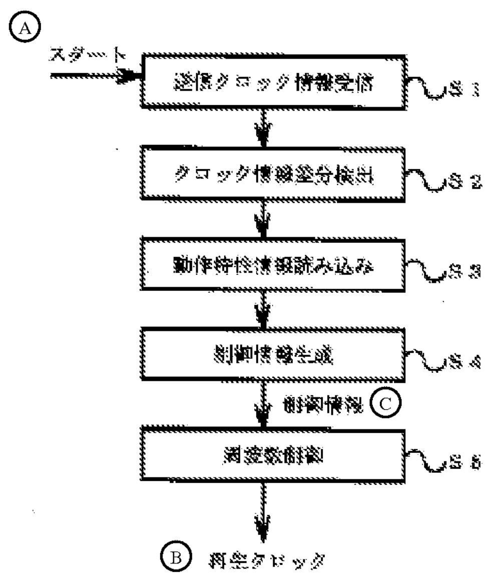


Figure 5

Key:
- A Start
- B Reproduction clock
- C Control information
- S1 Receive transmission clock information
- S2 Extract clock information difference

S3 Read operating characteristic information
S4 Generate control information
S5 Frequency control

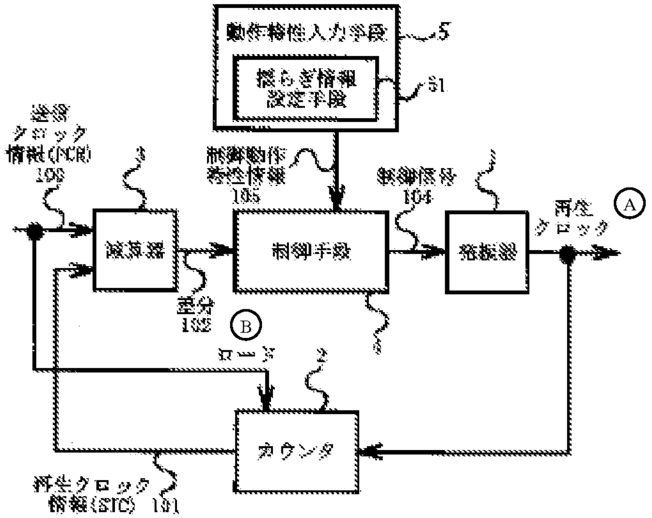


Figure 6

Key:
A Reproduction clock
B Load
1 Oscillator
2 Counter
3 Subtracter
4 Control means
5 Operating characteristic input means
51 Fluctuation information setting means
100 Transmission clock information (PCR)
101 Reproduction clock information (STC)
102 Difference
104 Control signal
105 Control operation characteristic information

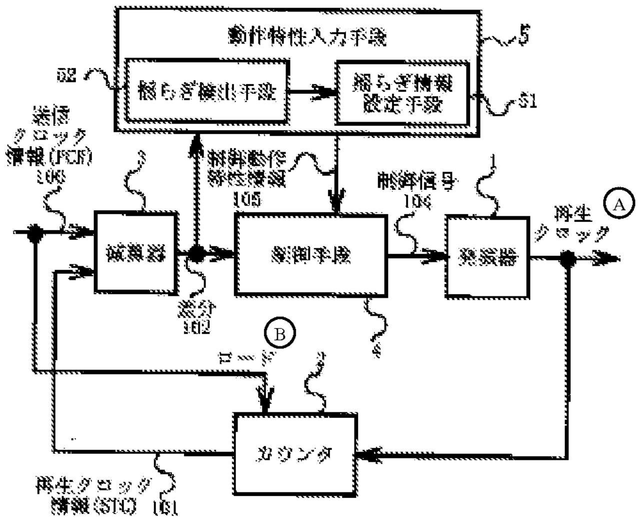


Figure 7

Key:

A	Reproduction clock
B	Load
1	Oscillator
2	Counter
3	Subtracter
4	Control means
5	Operating characteristic input means
51	Fluctuation information setting means
52	Fluctuation detection means
100	Transmission clock information (PCR)
101	Reproduction clock information (STC)
102	Difference
104	Control signal
105	Control operation characteristic information

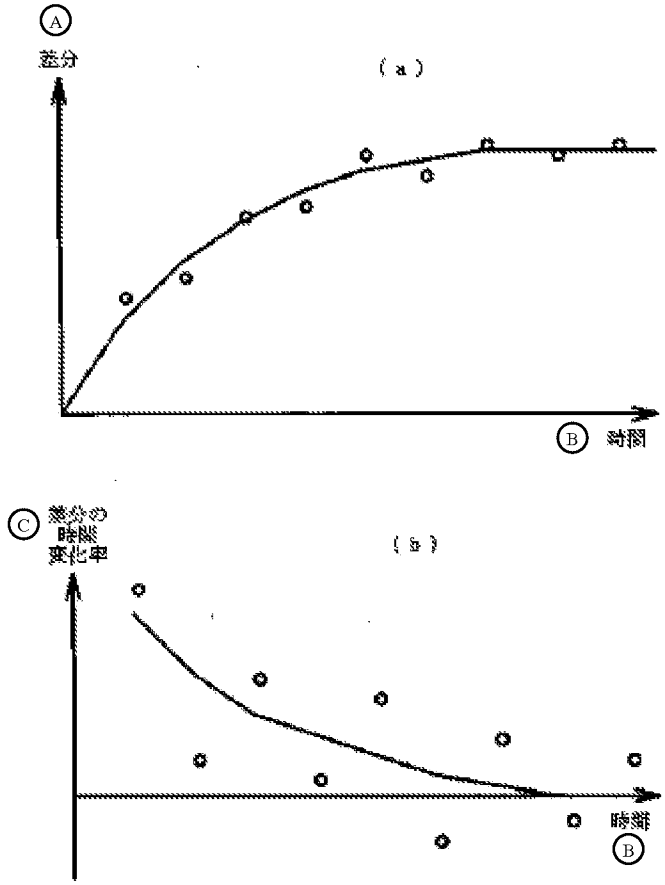


Figure 8

Key: A Difference
B Time
C Time rate of change in difference

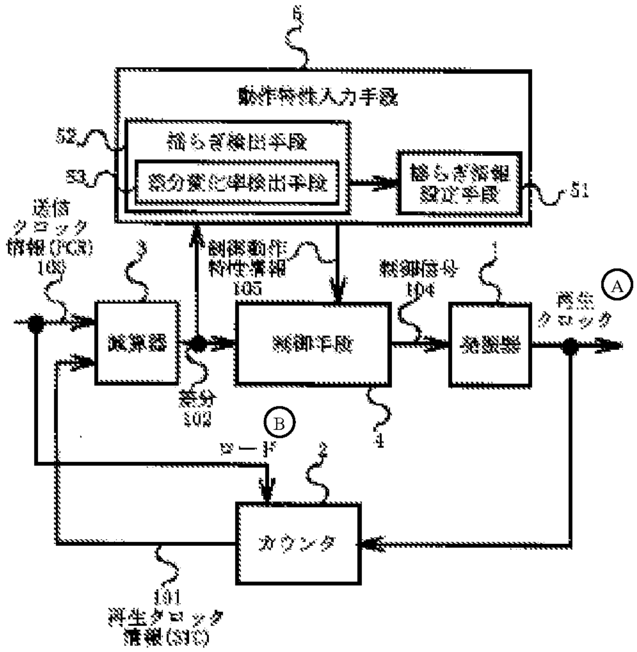


Figure 9

Key:

A	Reproduction clock
B	Load
1	Oscillator
2	Counter
3	Subtracter
4	Control means
5	Operating characteristic input means
51	Fluctuation information setting means
52	Fluctuation detection means
53	Difference change rate detection means
100	Transmission clock information (PCR)
101	Reproduction clock information (STC)
102	Difference
104	Control signal
105	Control operation characteristic information

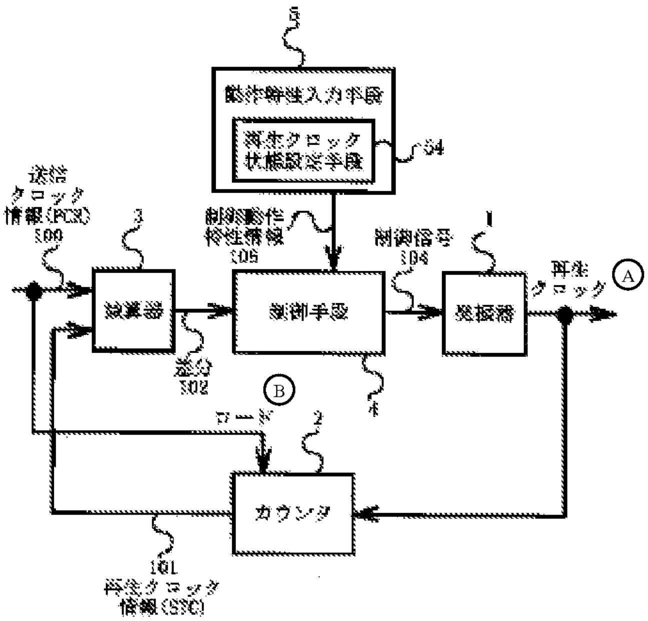


Figure 10

Key:
- A Reproduction clock
- B Load
- 1 Oscillator
- 2 Counter
- 3 Subtracter
- 4 Control means
- 5 Operating characteristic input means
- 54 Reproduction clock status-setting means
- 100 Transmission clock information (PCR)
- 101 Reproduction clock information (STC)
- 102 Difference
- 104 Control signal
- 105 Control operation characteristic information

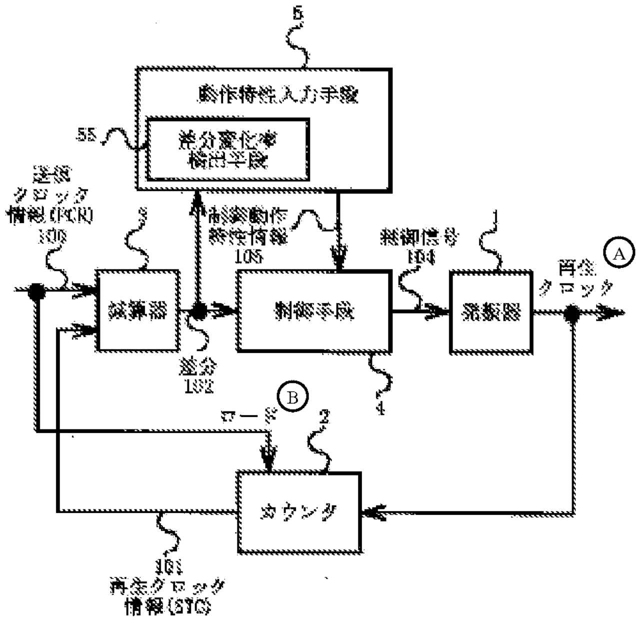


Figure 11

Key:

Key:	A	Reproduction clock
	B	Load
	1	Oscillator
	2	Counter
	3	Subtracter
	4	Control means
	5	Operating characteristic input means
	55	Difference change rate detection means
	100	Transmission clock information (PCR)
	101	Reproduction clock information (STC)
	102	Difference
	104	Control signal
	105	Control operation characteristic information

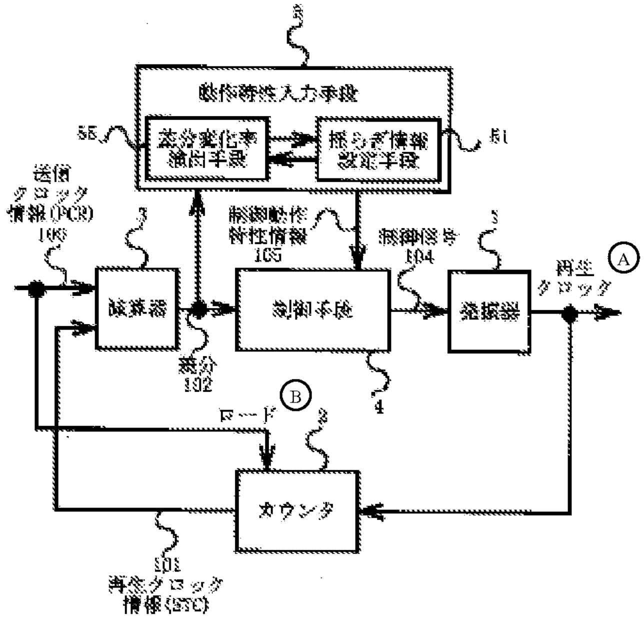


Figure 12

Key:
- A Reproduction clock
- B Load
- 1 Oscillator
- 2 Counter
- 3 Subtracter
- 4 Control means
- 5 Operating characteristic input means
- 51 Fluctuation information setting means
- 55 Difference change rate detection means
- 100 Transmission clock information (PCR)
- 101 Reproduction clock information (STC)
- 102 Difference
- 104 Control signal
- 105 Control operation characteristic information

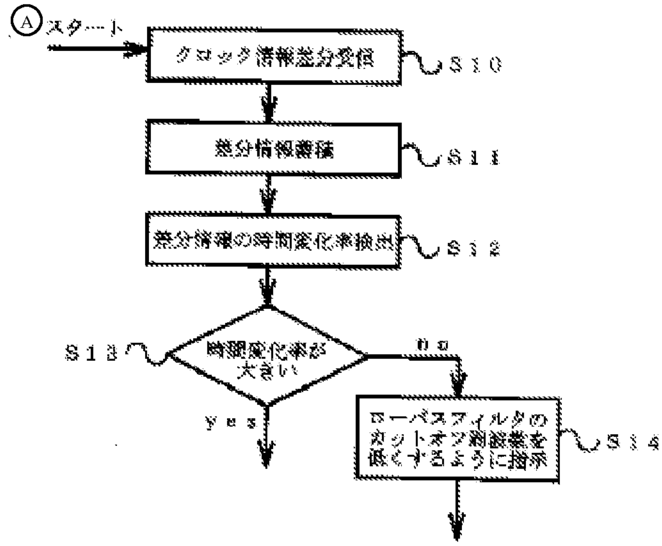


Figure 13

Key:
- A Start
- S10 Receive clock information difference
- S11 Store difference information
- S12 Detect time rate of change in difference information
- S13 Is time rate of change large?
- S14 Specify that cutoff frequency of low-pass filter be made low

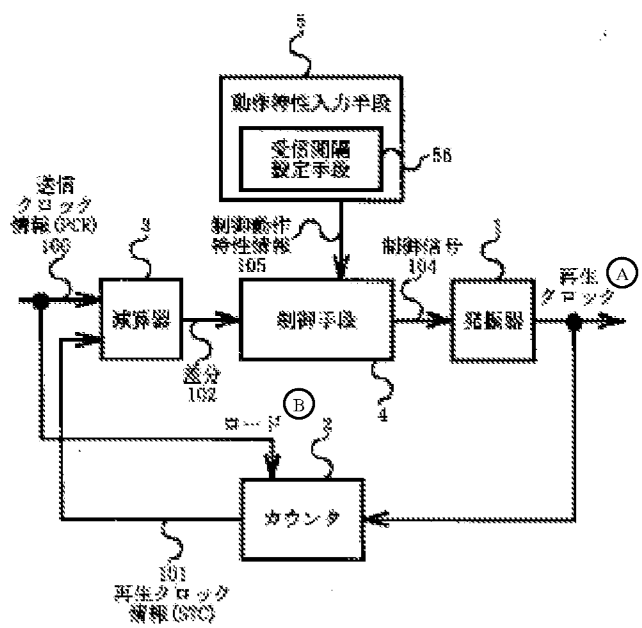


Figure 14

Key:
- A Reproduction clock
- B Load
- 1 Oscillator
- 2 Counter

3 Subtracter
4 Control means
5 Operating characteristic input means
56 Reception interval setting means
100 Transmission clock information (PCR)
101 Reproduction clock information (STC)
102 Difference
104 Control signal
105 Control operation characteristic information

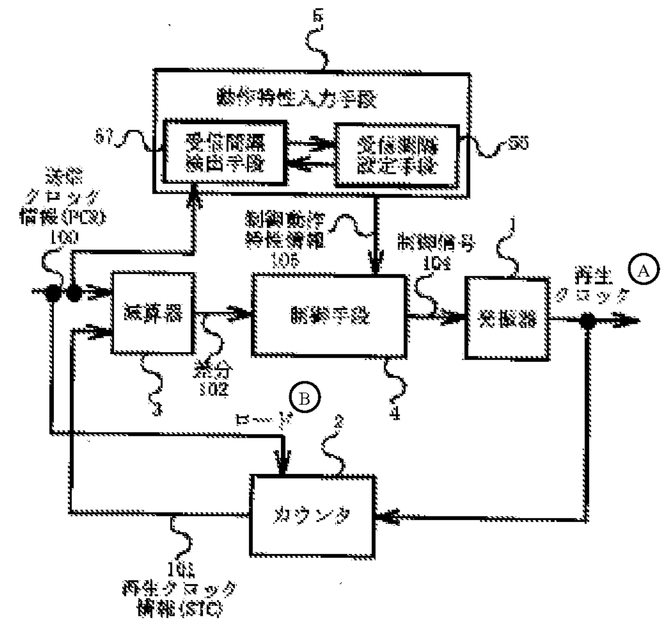


Figure 15

Key: A Reproduction clock
B Load
1 Oscillator
2 Counter
3 Subtracter
4 Control means
5 Operating characteristic input means
56 Reception interval setting means
57 Reception interval detection means
100 Transmission clock information (PCR)
101 Reproduction clock information (STC)
102 Difference
104 Control signal
105 Control operation characteristic information

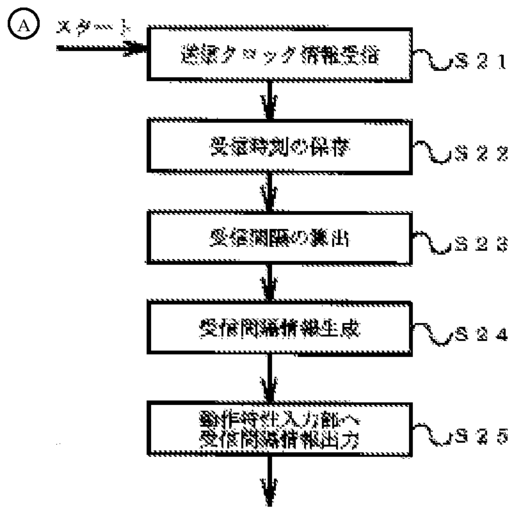


Figure 16

Key:
A Start
S21 Receive transmission clock information
S22 Save reception time
S23 Calculate reception interval
S24 Generate reception interval information
S25 Output reception interval information to operating characteristic input unit

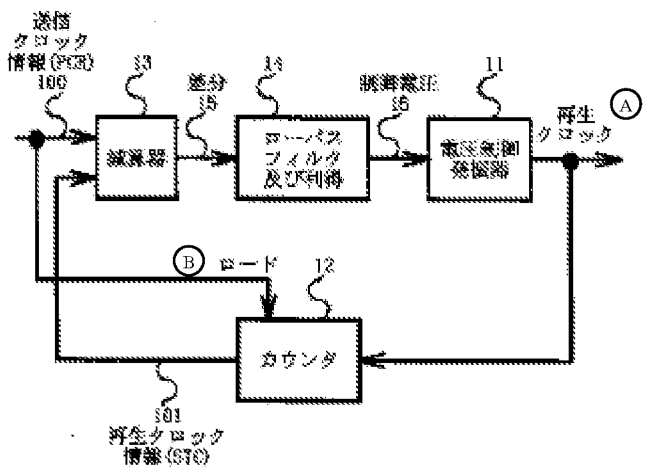


Figure 17

Key:
A Reproduction clock
B Load
11 Voltage control oscillator
12 Counter
13 Subtracter
14 Low-pass filter and gain [means]
15 Difference
16 Control voltage
100 Transmission clock information (PCR)
101 Reproduction clock information (STC)